Listing of Claims:

Claim 1 (currently amended): A method for estimating the total bandwidth between a first node and a second node in a communications network from a remote host comprising:

generating at the remote host a plurality of randomly-sized data packet pairs each having a first data packet and a second data packet of equivalent size;

sending from the remote host each of said first data packets to said first node;

sending from the remote host each of said second data packets to said second node by way of said first node;

receiving at the remote host a response message from each of said first and second nodes;

generating a set of first delay times indicative of the time each of said first data packets required to reach said first node based on the received response messages;

generating a set of second delay times indicative of the time each of said second data packets required to reach said second node based on the received response messages;

estimating the total bandwidth based on said set of first delay times and said set of second delay times.

Claim 2 (previously presented): The method of claim 1 wherein the steps of estimating the total bandwidth further comprises the steps of generating a first estimate indicative of total packet-size independent delay between said first node and said second node and a first estimate indicative of delay per byte between said first node and said second node using an estimation method.

Claim 3 (previously presented): The method of claim 2 wherein the first estimate indicative of the total packet-size independent delay, $\hat{\alpha}^0$, and the first estimate indicative of the delay per byte, $\hat{\beta}^0$, are generated according to the least trimmed squares estimation method using the following relationship:

$$\left(\hat{\alpha}^0, \hat{\beta}^0\right) = \arg\min_{\alpha,\beta} \sum_{i=1}^{q} \left(r_{(j)}^2(\alpha,\beta)\right)$$

wherein $r_{(j)}^2(\alpha,\beta)$ is the j[th] ordered statistics of the squared residuals.

Claim 4 (previously presented): The method of claim 2 wherein the step of estimating total hop delay further comprises the step of generating a final estimate of the total packet-size independent delay based on a Bayesian point analysis assuming that the first estimate

indicative of the delay per byte is correct.

Claim 5 (previously presented): The method of claim 4 wherein the Bayesian point analysis further assumes a right-skewed inverse Gaussian delay distribution.

Claim 6 (original): The method of claim 5 wherein the Bayesian point analysis for the final estimate of the total packet-size independent delay, α, is determined according to the following relationship:

$$\hat{\alpha} = E\left(\alpha \mid \hat{\beta}^{0}, \underset{\sim}{d}\right) = \frac{\int_0^\infty \int_0^\infty \alpha L\left(\alpha, \sigma \mid \hat{\beta}^{0}, \underset{\sim}{d}\right) d\sigma d\alpha}{\int_0^\infty \int_0^\infty L\left(\alpha, \sigma \mid \hat{\beta}^{0}, \underset{\sim}{d}\right) d\sigma d\alpha}$$

wherein

$$L\left(\alpha, \sigma \mid \hat{\beta}^{0}, \underset{\sim}{d}\right) = \prod_{i=1}^{m} \frac{1}{\sqrt{2\pi\sigma}} \left(\frac{\mu}{d_i}\right)^{\frac{3}{2}} e^{-\frac{1}{2\sigma^2} \frac{\mu}{d_i}\left(d_i - \mu\right)^2} \text{ and } \mu = \alpha + \hat{\beta}^{0} s.$$

Claim 7 (currently amended): The method of claim 1 wherein said plurality of randomly-sized data packet pairs is sent more than once to said first node and said second nodes and the set of first delay times and the set of second delay times are based on ~~the~~ a minimum delay for each packet size.

Claim 8 (original): The method of claim 2 wherein the first and second data packets are ICMP-Echo request data packets.

Claim 9 (original): The method of claim 2 wherein the first and second data packets are TCP data packets.

Claim 10 (original): The method of claim 2 wherein the first and second data packets are UDP data packets.

Claim 11 (currently amended): A method for estimating at a host the available bandwidth as a function of time between a first node and a second node in a communications network comprising the steps of:

generating a known quantity of traffic at a location remote from said host;

injecting said known quantity of traffic into the communications network;

generating a plurality of randomly-sized data packet pairs each having a first data packet and a second data packet of equivalent size;

sending each of said first data packets from said host to said first node;

sending each of said second data packets from said host to said second node by way of said first node;

receiving a response from each of first and second nodes indicating receipt of said data packets;

generating a set of first delay times indicative of the time each of said first data packets required to reach said first node based on the received response;

generating a set of second delay times indicative of the time each of said second data packets required to reach said second node based on the received response;

estimating a traffic and router characteristic parameters, (γ);

estimating the available bandwidth as a function of time based on said set of first delay times and said set of second delay times and the traffic and router characteristic parameter.

Claim 12 (previously presented): The method of claim 11 wherein the steps of generating and injecting a known quantity of generated traffic into the communications network comprises sending K data sets from a traffic generator and the step of estimating the traffic and router characteristic parameters (γ) according to nonlinear regression to solve the following relationship for said K sets of data

$$\alpha_k(t) = \gamma\left(\frac{C}{A_0 - r_k} - 1\right), \text{ k=1,....K.}$$

Claim 13 (previously presented): The method of claim 12 wherein α(t) is estimated for a specific time (t) using a Bayesian point analysis for the final estimate of the total packet-size independent delay, α, is determined according to the following relationship:

$$\hat{\alpha} = E\left(\alpha \mid \hat{\beta}^0, d\right) = \frac{\int_0^\infty \int_0^\infty \alpha L\left(\alpha, \sigma \mid \hat{\beta}^0, d\right) d\sigma d\alpha}{\int_0^\infty \int_0^\infty L\left(\alpha, \sigma \mid \hat{\beta}^0, d\right) d\sigma d\alpha}$$

wherein

$$L\left(\alpha,\sigma \mid \hat{\beta}^{0},\underset{\sim}{d}\right)=\prod_{i=1}^{m}\frac{1}{\sqrt{2\pi\sigma}}\left(\frac{\mu}{d_i}\right)^{\frac{3}{2}}e^{-\frac{1}{2\sigma^2}\frac{\mu}{d_i}\left(d_i-\mu\right)^2} \text{ and } \mu=\alpha+\hat{\beta}^{0}s.$$

Claim 14 (previously presented): The method of claim 11 wherein the step of estimating the available bandwidth as a function of time based on said set of first delay times and said second delay times and the traffic and router characteristic parameter is determined by the following relationship,

$$\hat{A}(t)=\frac{C}{\alpha(t)/\hat{\gamma}+1}.$$

Claim 15 (original): The method of claim 14 wherein $\alpha(t)$ is estimated for a specific time (t) using a Bayesian point estimate according to the following relationship:

$$\hat{\alpha}=E\left(\alpha \mid \hat{\beta}^{0},\underset{\sim}{d}\right)=\frac{\int_0^\infty\int_0^\infty \alpha L\left(\alpha,\sigma \mid \hat{\beta}^{0},\underset{\sim}{d}\right)d\sigma d\alpha}{\int_0^\infty\int_0^\infty L\left(\alpha,\sigma \mid \hat{\beta}^{0},\underset{\sim}{d}\right)d\sigma d\alpha}.$$

Claim 16 (previously presented): The method of claim 11 wherein the traffic and router characteristic parameters(γ) are re-estimated only upon changes in the network configuration or traffic conditions.

Claim 17 (currently amended): A system for the estimation of the bandwidth between two nodes in a communications network comprising:

a memory for storing an operating system and a bandwidth estimator program;

a processor in communication with said memory for executing instructions from said operating system and said bandwidth estimator program;

a network interface for sending and receiving data to and from said nodes in said communications network;

wherein said bandwidth estimator program generates a plurality of randomly-sized data packet pairs each having a first data packet and a second data packet of equivalent size, sends said plurality of said first data packets to said first node through said network interface, sends said plurality of said second data packets to said second node through said network interface <u>and by way of said first node</u>, receives a response from each of first and second

nodes through said network interface indicating receipt of said data packets, generates a set of first delay times indicative of the time each of said first data packets required to reach said first node, generates a set of second delay times indicative of the time each of said second data packets required to reach said second node and estimates the total bandwidth based on said set of first delay times and said set of second delay times.

Claim 18 (previously presented): The system of claim 17 further comprising a traffic generator for generating and injecting a known quantity of traffic into said communications network at a location remote from said network interface.

Claim 19 (previously presented): The system of claim 18 wherein said bandwidth estimator program further comprises means for estimating the traffic and router characteristic parameters (γ) and available bandwidth as a function of time based on said set of first delay times and said second delay times.

Claim 20 (original): The system of claim 17 further comprising an input/output interface for communication with an end-user thereby enabling an end-user to estimate total and available bandwidth between two nodes in a communication network.